

**EXAMPLE 12** Finding the Slope of a Line Perpendicular to Another Line

If a line has slope  $\frac{3}{2}$ , any line having slope  $-\frac{2}{3}$  is perpendicular to it.

**EXAMPLE 13** Finding the Equation of a Line Perpendicular to a Given Line

Find an equation of the line that contains the point  $(1, -2)$  and is perpendicular to the line  $x + 3y = 6$ . Graph the two lines.

**Solution** First write the equation of the given line in slope–intercept form to find its slope.

$$x + 3y = 6$$

$$3y = -x + 6 \quad \text{Proceed to solve for } y.$$

$$y = -\frac{1}{3}x + 2 \quad \text{Place in the form } y = mx + b.$$

The given line has slope  $-\frac{1}{3}$ . Any line perpendicular to this line will have slope 3.

Because the point  $(1, -2)$  is on this line with slope 3, use the point–slope form of the equation of a line.

$$y - y_1 = m(x - x_1) \quad \text{Point–slope form}$$

$$y - (-2) = 3(x - 1) \quad m = 3, x_1 = 1, y_1 = -2$$

To obtain other forms of the equation, proceed as follows:

$$y + 2 = 3(x - 1)$$

$$y + 2 = 3x - 3 \quad \text{Simplify.}$$

$$y = 3x - 5 \quad \text{Slope–intercept form}$$

$$3x - y = 5 \quad \text{General form}$$

Figure 44

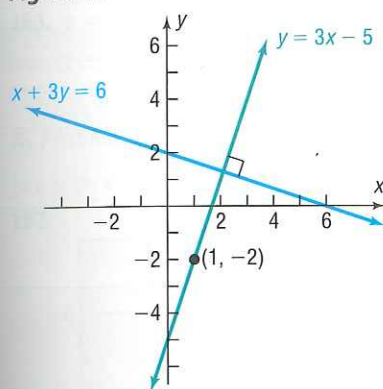


Figure 44 shows the graphs.

 **Now Work** PROBLEM 65

## F.3 Assess Your Understanding

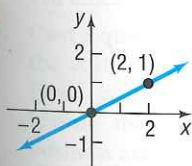
### Concepts and Vocabulary

- The slope of a vertical line is \_\_\_\_\_; the slope of a horizontal line is \_\_\_\_\_.
- For the line  $2x + 3y = 6$ , the  $x$ -intercept is \_\_\_\_\_ and the  $y$ -intercept is \_\_\_\_\_.
- A horizontal line is given by an equation of the form \_\_\_\_\_, where  $b$  is the \_\_\_\_\_.
- True or False** Vertical lines have an undefined slope.
- True or False** The slope of the line  $2y = 3x + 5$  is 3.
- True or False** The point  $(1, 2)$  is on the line  $2x + y = 4$ .
- Two nonvertical lines have slopes  $m_1$  and  $m_2$ , respectively. The lines are parallel if \_\_\_\_\_ and the \_\_\_\_\_ are unequal; the lines are perpendicular if \_\_\_\_\_.
- The lines  $y = 2x + 3$  and  $y = ax + 5$  are parallel if  $a =$  \_\_\_\_\_.
- The lines  $y = 2x - 1$  and  $y = ax + 2$  are perpendicular if  $a =$  \_\_\_\_\_.
- True or False** Perpendicular lines have slopes that are reciprocals of one another.

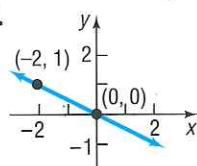
### Skill Building

In Problems 11–14, (a) find the slope of the line and (b) interpret the slope.

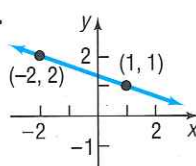
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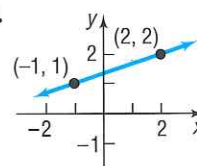
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13.



14.



In Problems 15–22, plot each pair of points and determine the slope of the line containing them. Graph the line.

15.  $(2, 3); (4, 0)$

16.  $(4, 2); (3, 4)$

17.  $(-2, 3); (2, 1)$

18.  $(-1, 1); (2, 3)$

19.  $(-3, -1); (2, -1)$

20.  $(4, 2); (-5, 2)$

21.  $(-1, 2); (-1, -2)$

22.  $(2, 0); (2, 2)$

In Problems 23–30, graph the line containing the point  $P$  and having slope  $m$ .

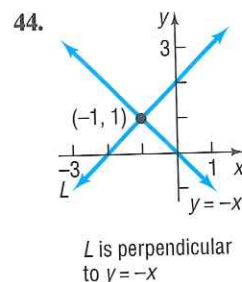
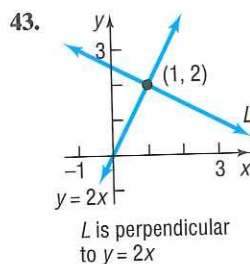
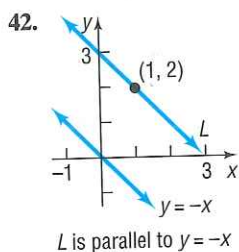
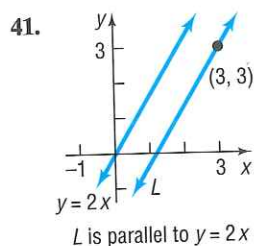
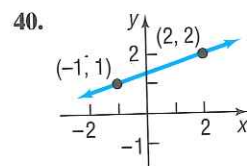
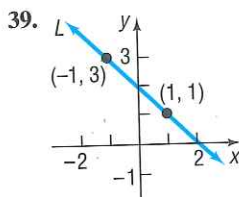
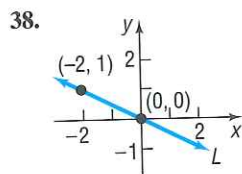
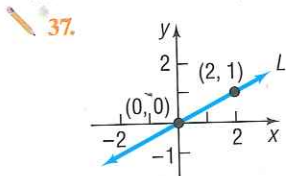
23.  $P = (1, 2); m = 3$     24.  $P = (2, 1); m = 4$     25.  $P = (2, 4); m = -\frac{3}{4}$     26.  $P = (1, 3); m = -\frac{2}{5}$   
 27.  $P = (-1, 3); m = 0$     28.  $P = (2, -4); m = 0$     29.  $P = (0, 3);$  slope undefined    30.  $P = (-2, 0);$  slope undefined

In Problems 31–36, the slope and a point on a line are given. Use this information to locate three additional points on the line. Answers may vary.

[Hint: It is not necessary to find the equation of the line. See Example 2.]

31. Slope 4; point  $(1, 2)$     32. Slope 2; point  $(-2, 3)$   
 33. Slope  $-\frac{3}{2}$ ; point  $(2, -4)$   
 34. Slope  $\frac{4}{3}$ ; point  $(-3, 2)$     35. Slope  $-2$ ; point  $(-2, -3)$   
 36. Slope  $-1$ ; point  $(4, 1)$

In Problems 37–44, find an equation of the line  $L$ .



In Problems 45–70, find an equation for the line with the given properties. Express your answer using either the general form or the slope-intercept form of the equation of a line, whichever you prefer.

45. Slope = 3; containing the point  $(-2, 3)$     46. Slope = 2; containing the point  $(4, -3)$   
 47. Slope =  $-\frac{2}{3}$ ; containing the point  $(1, -1)$     48. Slope =  $\frac{1}{2}$ ; containing the point  $(3, 1)$   
 49. Containing the points  $(1, 3)$  and  $(-1, 2)$     50. Containing the points  $(-3, 4)$  and  $(2, 5)$   
 51. Slope =  $-3$ ;  $y$ -intercept = 3    52. Slope =  $-2$ ;  $y$ -intercept =  $-2$   
 53.  $x$ -intercept = 2;  $y$ -intercept =  $-1$     54.  $x$ -intercept =  $-4$ ;  $y$ -intercept = 4  
 55. Slope undefined; containing the point  $(2, 4)$     56. Slope undefined; containing the point  $(3, 8)$   
 57. Horizontal; containing the point  $(-3, 2)$     58. Vertical; containing the point  $(4, -5)$   
 59. Parallel to the line  $y = 2x$ ; containing the point  $(-1, 2)$     60. Parallel to the line  $y = -3x$ ; containing the point  $(-1, 2)$   
 61. Parallel to the line  $2x - y = -2$ ; containing the point  $(0, 0)$     62. Parallel to the line  $x - 2y = -5$ ; containing the point  $(0, 0)$   
 63. Parallel to the line  $x = 5$ ; containing the point  $(4, 2)$     64. Parallel to the line  $y = 5$ ; containing the point  $(4, 2)$   
 65. Perpendicular to the line  $y = \frac{1}{2}x + 4$ ; containing the point  $(1, -2)$     66. Perpendicular to the line  $y = 2x - 3$ ; containing the point  $(1, -2)$   
 67. Perpendicular to the line  $2x + y = 2$ ; containing the point  $(-3, 0)$     68. Perpendicular to the line  $x - 2y = -5$ ; containing the point  $(0, 4)$   
 69. Perpendicular to the line  $x = 8$ ; containing the point  $(3, 4)$     70. Perpendicular to the line  $y = 8$ ; containing the point  $(3, 4)$

In Problems 71–90, find the slope and  $y$ -intercept of each line. Graph the line.

71.  $y = 2x + 3$       72.  $y = -3x + 4$       73.  $\frac{1}{2}y = x - 1$       74.  $\frac{1}{3}x + y = 2$       75.  $y = \frac{1}{2}x + 2$   
 76.  $y = 2x + \frac{1}{2}$       77.  $x + 2y = 4$       78.  $-x + 3y = 6$       79.  $2x - 3y = 6$       80.  $3x + 2y = 6$   
 81.  $x + y = 1$       82.  $x - y = 2$       83.  $x = -4$       84.  $y = -1$       85.  $y = 5$   
 86.  $x = 2$       87.  $y - x = 0$       88.  $x + y = 0$       89.  $2y - 3x = 0$       90.  $3x + 2y = 0$

In Problems 91–100, (a) find the intercepts of the graph of each equation and (b) graph the equation.

91.  $2x + 3y = 6$       92.  $3x - 2y = 6$       93.  $-4x + 5y = 40$       94.  $6x - 4y = 24$   
 95.  $7x + 2y = 21$       96.  $5x + 3y = 18$       97.  $\frac{1}{2}x + \frac{1}{3}y = 1$       98.  $x - \frac{2}{3}y = 4$   
 99.  $0.2x - 0.5y = 1$       100.  $-0.3x + 0.4y = 1.2$   
 101. Find an equation of the  $x$ -axis.      102. Find an equation of the  $y$ -axis.

In Problems 103–106, the equations of two lines are given. Determine whether the lines are parallel, perpendicular, or neither.

103.  $y = 2x - 3$       104.  $y = \frac{1}{2}x - 3$       105.  $y = 4x + 5$       106.  $y = -2x + 3$   
 $y = 2x + 4$        $y = -2x + 4$        $y = -4x + 2$        $y = -\frac{1}{2}x + 2$

In Problems 107–110, match each graph with the correct equation:

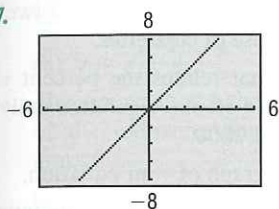
(a)  $y = x$

(b)  $y = 2x$

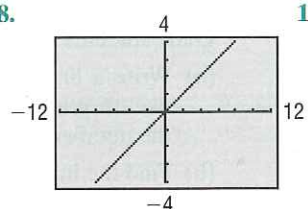
(c)  $y = \frac{x}{2}$

(d)  $y = 4x$

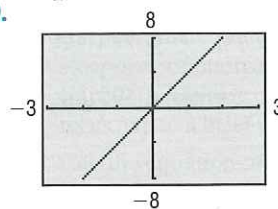
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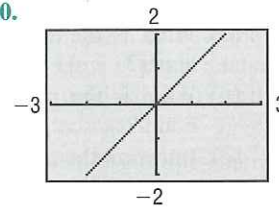
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109.



110.



## Applications and Extensions

111. **Geometry** Use slopes to show that the triangle whose vertices are  $(-2, 5)$ ,  $(1, 3)$ , and  $(-1, 0)$  is a right triangle.
112. **Geometry** Use slopes to show that the quadrilateral whose vertices are  $(1, -1)$ ,  $(4, 1)$ ,  $(2, 2)$ , and  $(5, 4)$  is a parallelogram.
113. **Geometry** Use slopes to show that the quadrilateral whose vertices are  $(-1, 0)$ ,  $(2, 3)$ ,  $(1, -2)$ , and  $(4, 1)$  is a rectangle.
114. **Geometry** Use slopes and the distance formula to show that the quadrilateral whose vertices are  $(0, 0)$ ,  $(1, 3)$ ,  $(4, 2)$ , and  $(3, -1)$  is a square.
115. **Truck Rentals** A truck rental company rents a moving truck for one day by charging \$39 plus \$0.60 per mile. Write a linear equation that relates the cost  $C$ , in dollars, of renting the truck to the number  $x$  of miles driven. What is the cost of renting the truck if the truck is driven 110 miles? 230 miles?
116. **Cost Equation** The **fixed costs** of operating a business are the costs incurred regardless of the level of production. Fixed costs include rent, fixed salaries, and costs of leasing machinery. The **variable costs** of operating a business are the costs that change with the level of output. Variable costs include raw materials, hourly wages, and electricity. Suppose that a manufacturer of jeans has fixed daily costs of \$500 and variable costs of \$8 for each pair of jeans manufactured. Write a linear equation that relates the daily cost  $C$ , in dollars, of manufacturing the jeans to the number  $x$  of jeans manufactured. What is the cost of manufacturing 400 pairs of jeans? 740 pairs?
117. **Cost of Driving a Car** The annual fixed costs for owning a small sedan are \$6735, assuming the car is completely paid for. The cost to drive the car is approximately \$0.45 per mile. Write a linear equation that relates the cost  $C$  and the number  $x$  of miles driven annually.  
*Source: AAA, April 2012*
118. **Wages of a Car Salesperson** Dan receives \$375 per week for selling new and used cars at a car dealership in Oak Lawn, Illinois. In addition, he receives 5% of the profit on any sales that he generates. Write a linear equation that represents Dan's weekly salary  $S$  when he has sales that generate a profit of  $x$  dollars.
119. **Electricity Rates in Illinois** Commonwealth Edison Company supplies electricity to residential customers for a monthly customer charge of \$13.04 plus 10.62 cents per kilowatt-hour for up to 800 kilowatt-hours (kw-hr).